Transmission measurements at 1.55µm on Photonic-Crystal ultra-short bend waveguides fabricated on InP based guiding layer.

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Abstract: The wavelength dependent transmission through a double-60°bend waveguide defined in a two-dimensional Photonic Crystal (2D PC) is measured on an extended WDM range (1500-1585nm). The fabrication of the Photonic Crystal into a GaInAsP confining layer on an InP substrate using CH4-based Reactive Ion Etching (RIE) is also reported.

Objective: Recent reports of efficient waveguiding in Photonic Crystal (PC) slab [1,2,3] demonstrate the potential of this structuration of the semiconductor material. The approach investigated here is the use of a thin slab perforated with a 2D PC [4], the light being vertically confined in a GaInAsP high index waveguide. 2D PC in plane guiding structures fabricated on InP substrate allow the implementation of Photonic Integrated Circuits -PIC- that could then include active devices. For ultra-compact PIC assembly, ultra-short bends are a prerequisite. We present here a spectral investigation of the transmission through an ultra-short double-60° bend PC channel.

Description: The confinement in the vertical direction is ensured using a GSMBE grown 500nm thick GaInAsP layer, which has a photoluminescence peak at 1.22µm, and is capped by a InP protecting layer [5]. The 2D PC consists of a triangular array of holes. Removing 2 or 3 rows of holes forms a line defect sustaining propagating modes [6]. For the choice of PC parameters, the band-gap being usually large enough to cover the WDM band, the issue of hole size has to be considered with respect to the amount of losses [7]. The PC period a=450nm is chosen in order to allow 1.55µm wavelength to lie within its gap.

PC is defined by e-beam lithography in PMMA resist, then transferred in a SiN layer which is used as a mask for RIE etching. Calibration of the CH4-based RIE dry-etching process has been done for hole diameters ranging from 150 to 900nm (Fig.1). We found that the etched depth reached is directly related to the hole diameter, but is not related to the air filling factor (for air filling factor lower than 0.5). In order to intercept more than 99% of the propagating mode field, holes have to be deeper than 1µm. Calibration measurements reported on Fig.1 indicate that this is feasible if we work with holes diameters in the range of 250-300nm, which corresponds to an air filling factor ranging from 0.3 to 0.4 (for a PC period a=450nm). A SEM cross section view of a three-missing-rows waveguide is shown on Fig.2, the etched depth attained is 1.3µm for 310nm holes diameter; note that the guiding GaInAsP layer has been intentionally wet-chemically selectively etched to be visible. Straight guides and double-60° bends were fabricated in this three-missing-rows guiding configuration. For reproducible coupling in and out of the PC guiding section, the PC guide is inserted between two monomode ridge access guides. The structure measured is detailed on Fig.3, also with a SEM top view of the double-60° bend.

Results and discussion: Measurements are performed using a fiber-to-fiber set-up in TE polarization. A constant optical power is launched from a tunable source (1500-1585nm). The power level collected on the output ridge guide after transmission through a double-60° bend is plotted on Fig.4, versus wavelength. A straight PC guide of the same total PC length is also shown. Both measurements have been deconvolved from the several Fabry-Perot fringe patterns arising from reflections not only at the facets but also at the transitions between the ridge access guide and the PC guide. The straight PC guide exhibits a dip that we could attribute to a mini stop-band [8], whereas the double-60° bend shows a specific transmission feature that we may relate to reflections at the very corners, but the transmission in the WDM window appears to be flat. Quantitative evaluation of reflection level and of propagation losses, which require a large number of samples of different lengths, are in progress. Also, different PC guide widths have been fabricated and are being measured.

Conclusion: This result of a constant transmission in the WDM window already demonstrates the ability of Photonic Crystal bends to allow propagating modes in the configuration of bends as short as the light wavelength. Optimized designs for low-reflection corners are under investigation.

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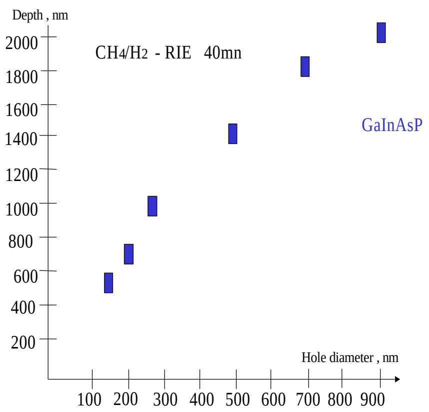

Fig.1: Etched depth versus hole diameter

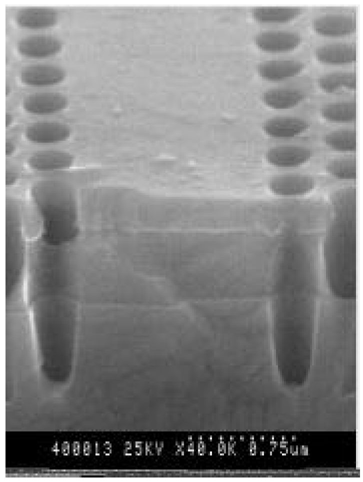

Fig.2: SEM picture of a 3-missing-rows waveguide (GaInAsP layer intentionally selectively etched)

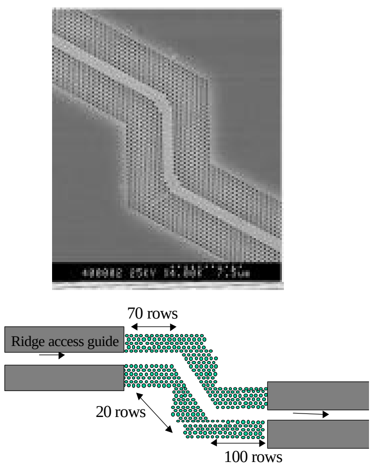

Fig.3 : Schematic of the fabricated double-60° bend, SEM picture in the case of 3-missing -rows waveguide

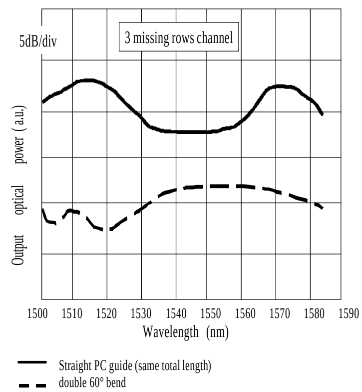

Fig.4 : Transmitted power versus wavelength straight PC guide, and double-60° bend